APPENDIX F

Fiddler Crab Trace Element and Total DDT Statistical Analysis

This appendix presents a statistical analysis of the trace element and total DDT data for fiddler crabs. To distinguish sampling areas that may be significantly different from each other, the means from all areas, including the reference location, were compared. Nonparametric Kruskal-Wallis tests were conducted, along with parametric ANOVA followed by multiple comparisons. Results from these tests were the same; for ease of presentation, only the results of the ANOVA tests are discussed below.

In these calculations, the method detection limit for trace elements was used to represent values reported as non-detects. For total DDT only the detected compounds were summed, that is, non-detects were treated as zeros. Since nonparametric tests rely on ranks, and not absolute values, this method of accounting for non-detects tends to have marginal impact on results. For total DDT, only detected values for metabolites were summed. An alpha of 0.05 was applied for significant findings (a ρ value lower than this indicates a statistically significant difference exists among some sampling areas). The sampling areas were:

Area 1: Downgradient from SWMU 7
Area 2: Downgradient from AOCs J and R
Area 3: Laguna Kiani
Area 4: Laguna Kiani South
Area 5: Boca Quebrada
Area 6: Laguna Playa Grande
Area 7: Mosquito Bay
Area 8: Puerto Ferro
Area 9: Red Beach
Area 10: Blue Beach
Area 11: Bahia Tapon
Area 12: Live Impact Area (LIA)

The reference sampling location was:

Area 14: Humacao Wildlife Reserve, Main Island Reference

The ANOVA table splits the variability observed in concentrations of each trace element into two components: a between-areas component and a within-areas component. The variability of these two components is then compared by calculating an *F-Ratio*, which is the ratio of the between/among-areas components. If the ratio is sufficiently large (i.e., there is much more variability between areas than within), then the probability (ρ-value) that the mean concentrations at all areas are even is small. A ρ-value less than 0.05 is associated with a 95% confidence level and is generally considered significant. To determine which means are different from each other, a Multiple Range test was performed.

In the Multiple Range test, area means are ranked from lowest to greatest. Groups with means that cannot be distinguished from each other (i.e., homogeneous groups) are then identified using columns of X's. Within each column, the concentrations joined by X's form a group of means within which there are no statistically significant differences (using Fisher's Least Significant Difference procedure). With this approach, there is a 5% risk of calling any given pair of means different when they are not. Because the area means span a range, there are often columns of homogeneous groups that overlap other columns of similarly homogeneous groups.

Graphs are included to further illustrate differences between areas. In the Analysis of Means plots, areas are ordered across the graph, and the mean at each area is plotted showing its distance from the overall grand mean of concentrations (the blue line). Upper and lower decision limit lines (the red lines) are calculated and plotted such that pair-wise indications of differences have a 95% confidence level associated with them. Areas with extreme mean values (those different than the overall grand mean of all areas) are indicated by plotting above or below the decision limit lines.

There were ten trace elements for which at least one fiddler crab sample exceeded the relevant ecological screening benchmark. To further portray the data, and graphically display the variability within each area associated with these ten trace elements, additional graphs for these elements are included. In these graphs, the area mean is plotted with a ● and the variability about that mean is indicated by plotting error bars above and below the mean. Error bars show plus or minus one standard deviation from the mean.

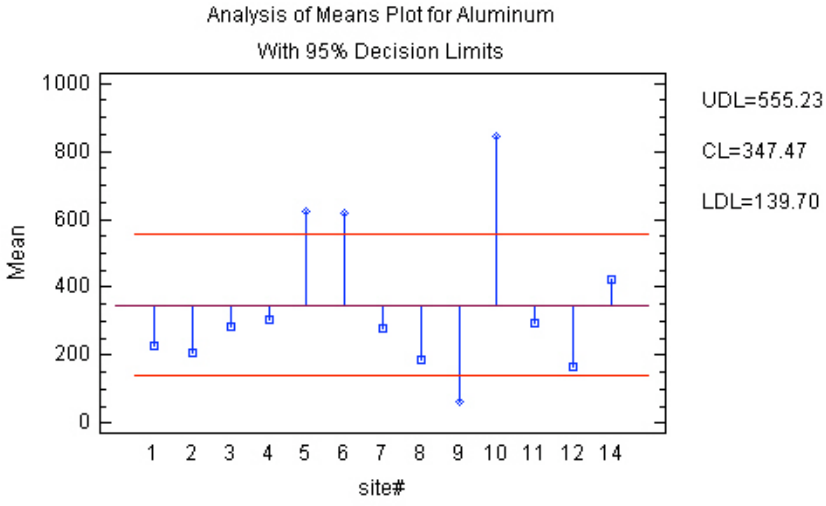
ANOVA Table for Aluminum by site#

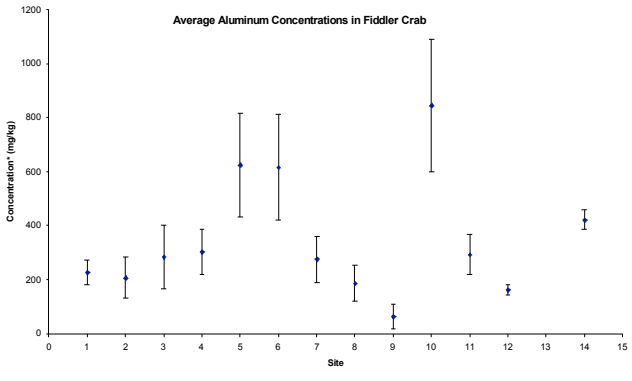
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	1.77249E6	12	147708.	10.38	0.0000
Within groups	369947.	26	14228.7		
Total (Corr.)	2.14244E6	38			

Multiple Range Tests for Aluminum by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	64.7333	X
12	3	163.333	XX
8	3	187.333	XX
2	3	207.667	XX
1	3	227.0	XXX
7	3	276.333	XX
3	3	284.333	XX
11	3	293.333	XX
4	3	303.667	XX
14	3	421.667	XX
6	3	616.333	XX
5	3	625.667	X
10	3	845.667	X





* Non-detected concentrations are plotted as the MDL

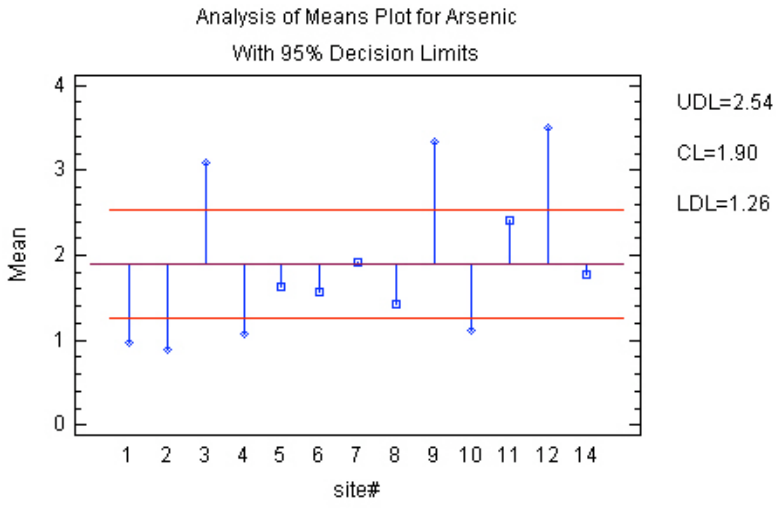
ANOVA Table for Arsenic by site#

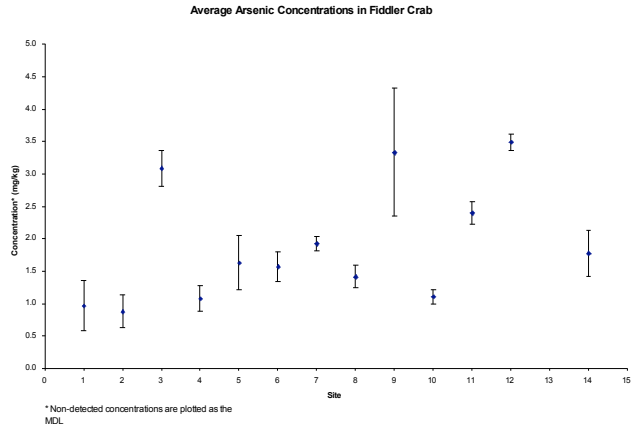
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	29.7125	12	2.47604	18.23	0.0000
Within groups	3.53047	26	0.135787		
Total (Corr.)	33.243	38			

Multiple Range Tests for Arsenic by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
2	3	0.88	X
1	3	0.97	XX
4	3	1.08	XXX
10	3	1.11	XXX
8	3	1.41667	XXXX
6	3	1.57333	XXX
5	3	1.63	XX
14	3	1.77667	X
7	3	1.92667	XX
11	3	2.40333	X
3	3	3.09	X
9	3	3.33333	X
12	3	3.49667	X





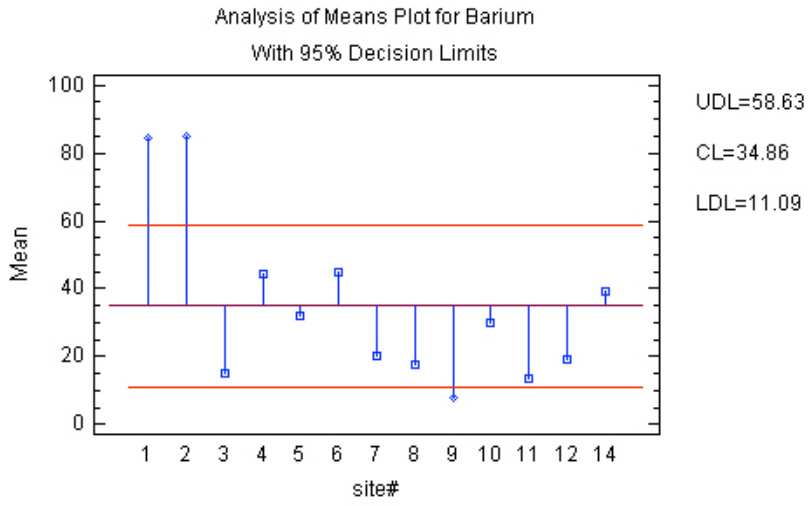
ANOVA Table for Barium by site#

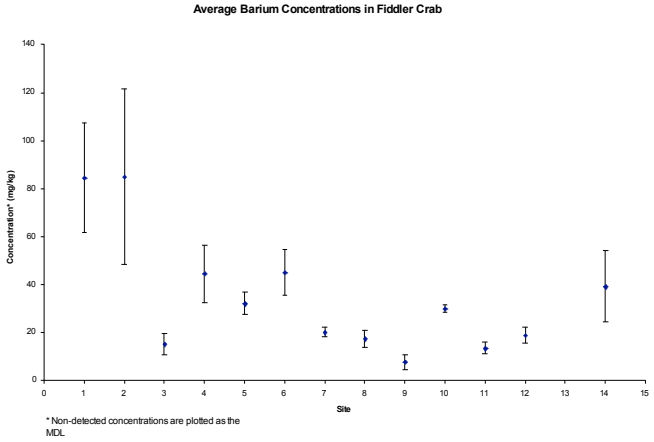
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	22750.4	12	1895.86	10.18	0.0000
Within groups	4843.2	26	186.277		
Total (Corr.)	27593.6	38			

Multiple Range Tests for Barium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	7.78	X
11	3	13.4667	XX
3	3	15.1333	XX
8	3	17.4	XXX
12	3	18.9	XXX
7	3	20.1	XXX
10	3	30.0	XXXX
5	3	32.1	XXX
14	3	39.2	XX
4	3	44.5667	X
6	3	45.0333	X
1	3	84.5667	X
2	3	84.9333	X





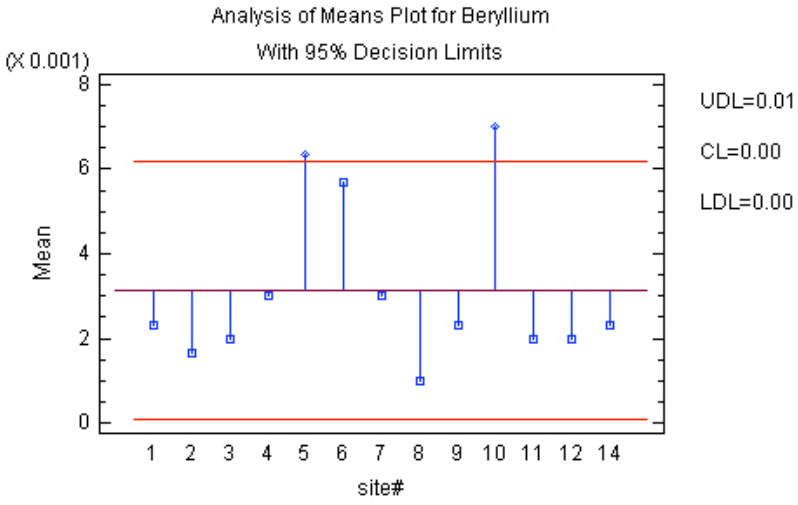
ANOVA Table for Beryllium by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.000132359	12	0.0000110299	3.58	0.0031
Within groups	0.00008	26	0.00000307692		
Total (Corr.)	0.000212359	38			

Multiple Range Tests for Beryllium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
8	3	0.001	X
2	3	0.00166667	X
12	3	0.002	X
3	3	0.002	X
11	3	0.002	X
14	3	0.00233333	X
1	3	0.00233333	X
9	3	0.00233333	X
7	3	0.003	XX
4	3	0.003	XX
6	3	0.00566667	XX
5	3	0.00633333	X
10	3	0.007	X



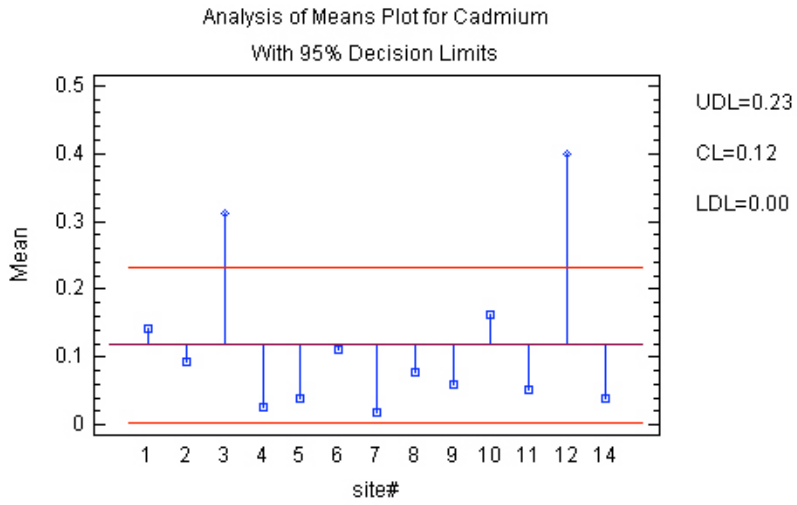
ANOVA Table for Cadmium by site#

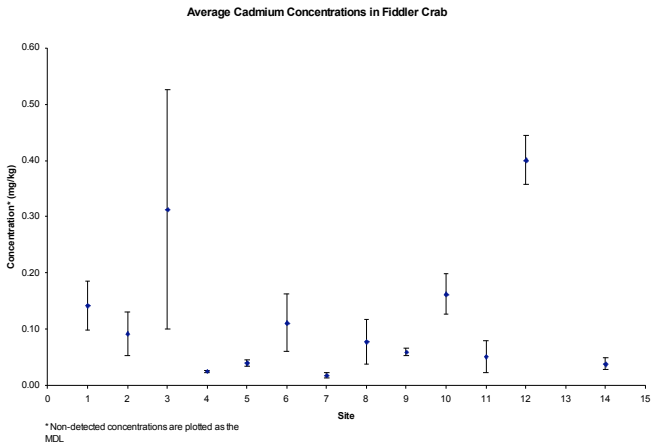
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.484418	12	0.0403681	9.28	0.0000
Within groups	0.113111	26	0.00435041		
Total (Corr.)	0.597528	38			

Multiple Range Tests for Cadmium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
7	3	0.018	X
4	3	0.0253333	X
14	3	0.0383333	XX
5	3	0.04	XX
11	3	0.0513333	XX
9	3	0.0596667	XXX
8	3	0.0776667	XXX
2	3	0.0926667	XXX
6	3	0.111333	XXX
1	3	0.142333	XX
10	3	0.162333	X
3	3	0.313	X
12	3	0.400333	X





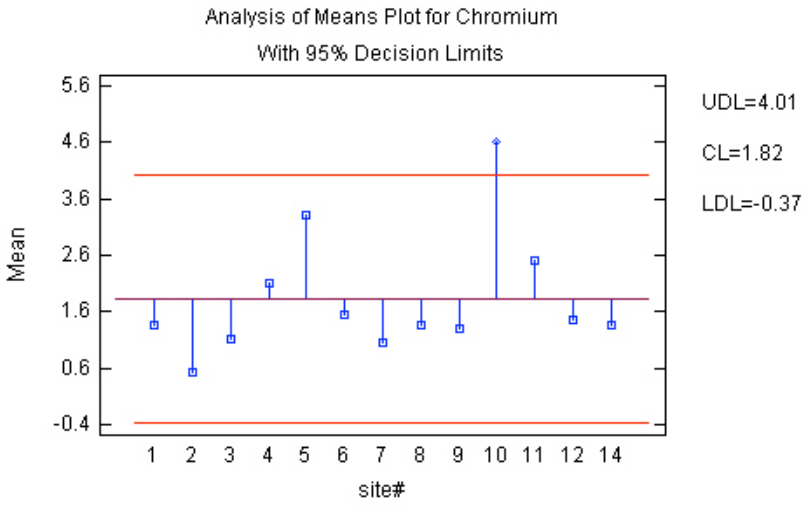
ANOVA Table for Chromium by site#

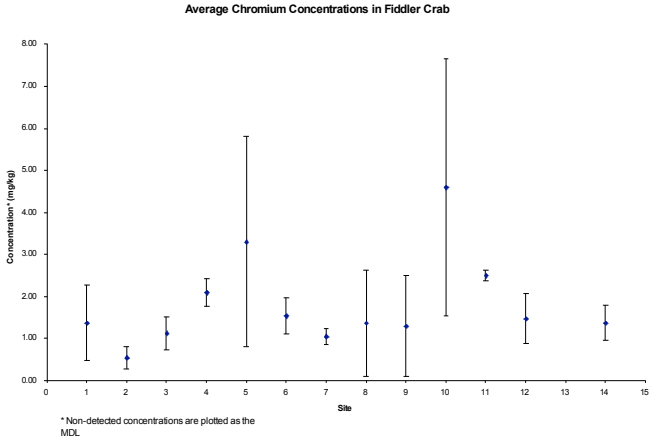
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	42.7346	12	3.56122	2.25	0.0406
Within groups	41.1418	26	1.58238		
Total (Corr.)	83.8764	38			

Multiple Range Tests for Chromium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
2	3	0.546667	X
7	3	1.05	X
3	3	1.12667	X
9	3	1.29667	XX
1	3	1.37	XX
14	3	1.37	XX
8	3	1.37	XX
12	3	1.47	XX
6	3	1.53667	XX
4	3	2.09333	XX
11	3	2.5	XXX
5	3	3.30333	XX
10	3	4.6	X





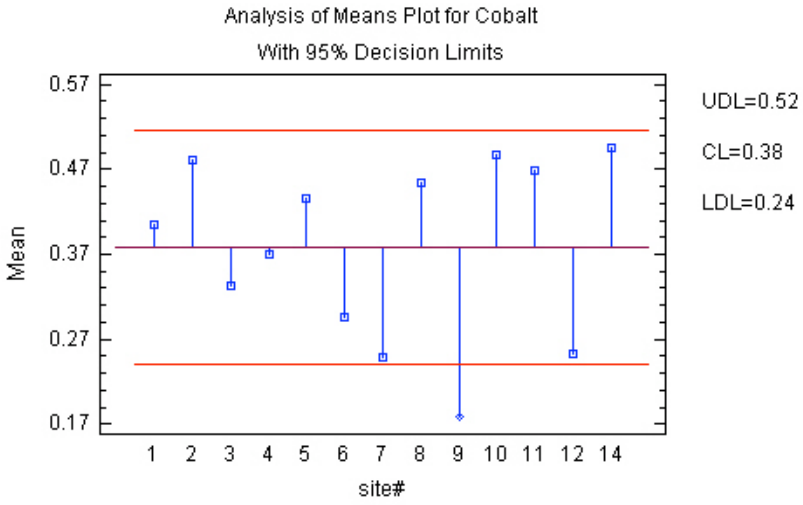
ANOVA Table for Cobalt by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.407161	12	0.0339301	5.42	0.0002
Within groups	0.162734	26	0.006259		
Total (Corr.)	0.569895	38			

Multiple Range Tests for Cobalt by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	0.177667	X
7	3	0.249	XX
12	3	0.252333	XX
6	3	0.295333	XXX
3	3	0.334	XXX
4	3	0.370333	XXXX
1	3	0.405333	XXX
5	3	0.435	XX
8	3	0.454667	XX
11	3	0.469333	X
2	3	0.480333	X
10	3	0.487333	X
14	3	0.495	X



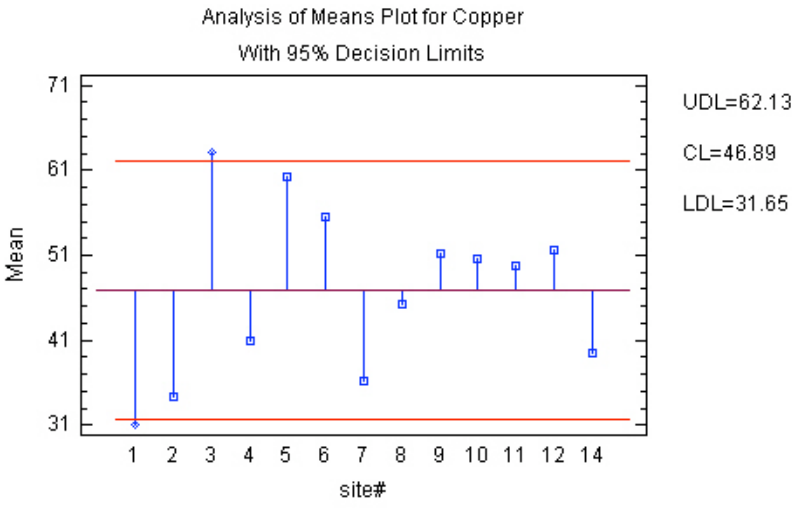
ANOVA Table for Copper by site#

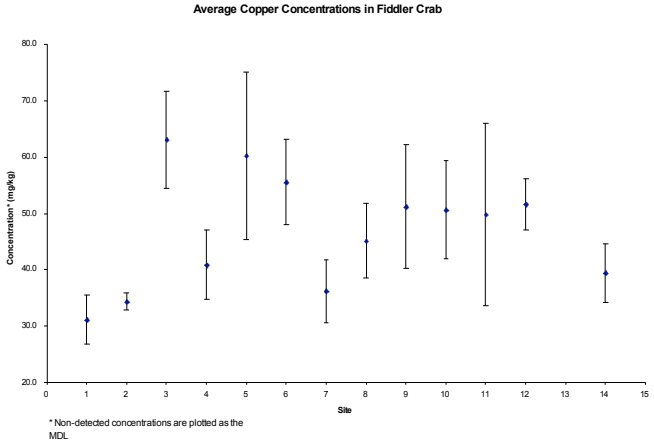
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	3603.13	12	300.261	3.92	0.0017
Within groups	1991.55	26	76.5979		
Total (Corr.)	5594.68	38			

Multiple Range Tests for Copper by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
1	3	31.1	X
2	3	34.3333	X
7	3	36.2333	XX
14	3	39.4333	XXX
4	3	40.8333	XXX
8	3	45.1667	XXXX
11	3	49.8333	XXXX
10	3	50.6667	XXXX
9	3	51.2333	XXX
12	3	51.6667	XXX
6	3	55.6	XX
5	3	60.3	X
3	3	63.1667	X





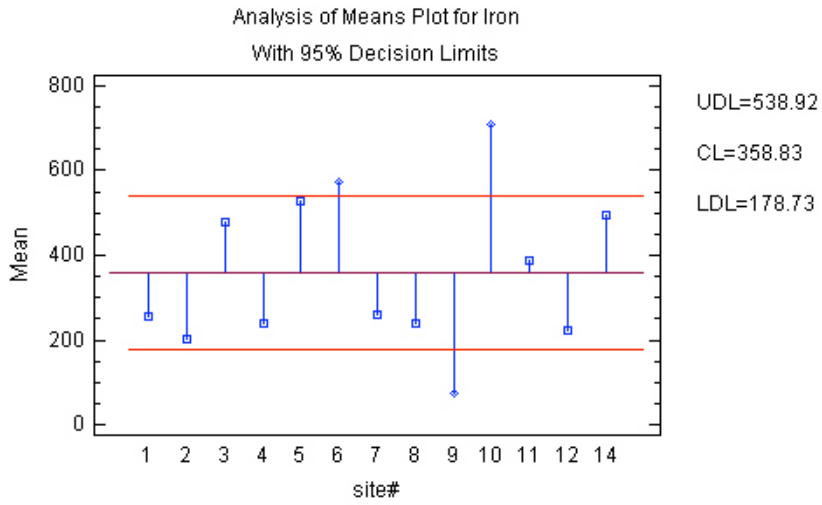
ANOVA Table for Iron by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	1.20708E6	12	100590.	9.41	0.0000
Within groups	277961.	26	10690.8		
Total (Corr.)	1.48504E6	38			

Multiple Range Tests for Iron by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	75.0667	X
2	3	204.0	XX
12	3	223.0	XXX
4	3	238.0	XXX
8	3	239.333	XXX
1	3	254.0	XX
7	3	261.667	XX
11	3	387.333	XX
3	3	479.0	XX
14	3	496.333	XX
5	3	526.667	XX
6	3	571.333	XX
10	3	709.0	X



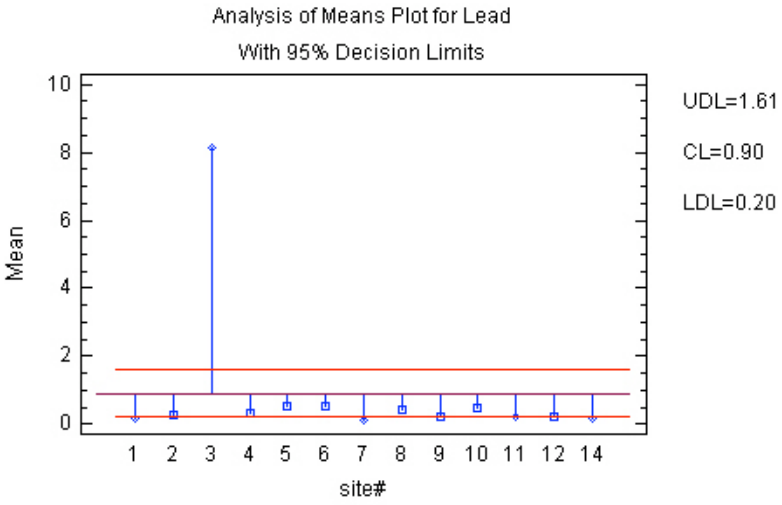
ANOVA Table for Lead by site#

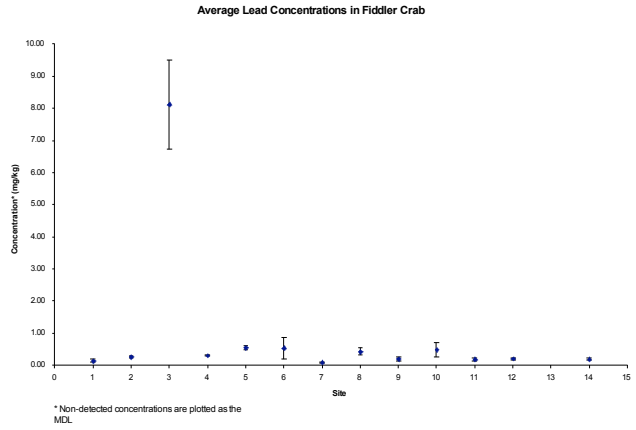
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	170.592	12	14.216	87.07	0.0000
Within groups	4.24514	26	0.163275		
Total (Corr.)	174.837	38			

Multiple Range Tests for Lead by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
7	3	0.0966667	X
1	3	0.143333	X
14	3	0.188333	X
11	3	0.193333	X
9	3	0.2	X
12	3	0.21	X
2	3	0.260333	X
4	3	0.31	X
8	3	0.429333	X
10	3	0.49	X
6	3	0.536667	X
5	3	0.55	X
3	3	8.13	X





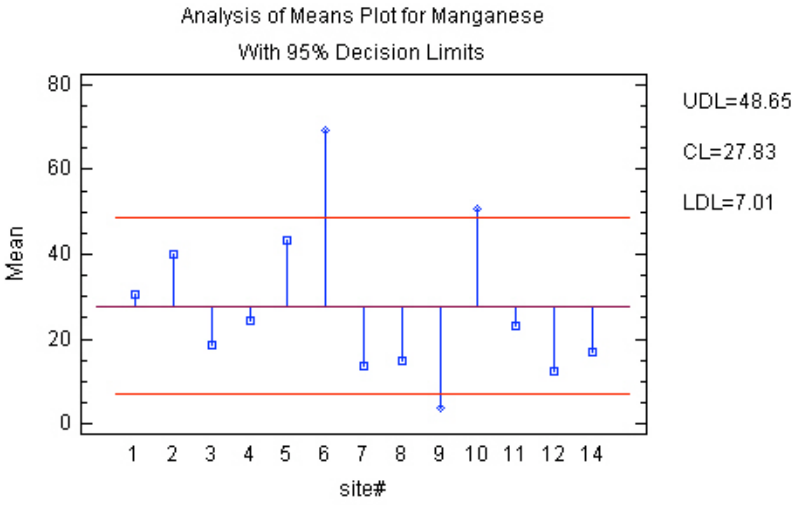
ANOVA Table for Manganese by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	12143.0	12	1011.92	7.08	0.0000
Within groups	3716.02	26	142.924		
Total (Corr.)	15859.0	38			

Multiple Range Tests for Manganese by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	3.66	X
12	3	12.24	XX
7	3	13.5667	XX
8	3	14.9667	XX
14	3	17.1333	XX
3	3	18.7667	XX
11	3	23.2333	XXX
4	3	24.5667	XX
1	3	30.4333	XX
2	3	40.1	XX
5	3	43.2	XX
10	3	50.8333	XX
6	3	69.0667	X



ANOVA Table for Magnesium by site#

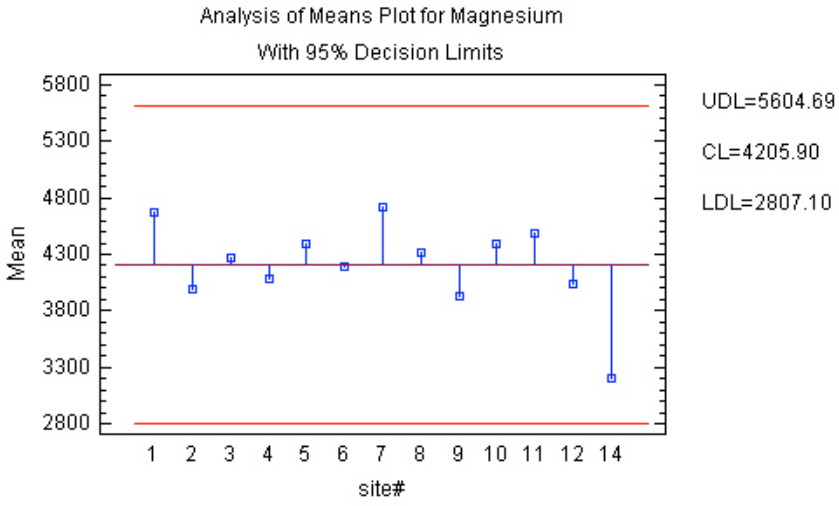
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	5.44881E6	12	454068.	0.70	0.7337
Within groups	1.67689E7	26	644959.		
Total (Corr.)	2.22177E7	38			

No differences in magnesium among areas are indicated.
The multiple range test results are presented here just to display site rankings and mean values per site.

Multiple Range Tests for Magnesium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
14	3	3206.67	X
9	3	3923.33	XX
2	3	3990.0	XX
12	3	4033.33	XX
4	3	4080.0	XX
6	3	4190.0	XX
3	3	4273.33	XX
8	3	4320.0	XX
5	3	4393.33	XX
10	3	4393.33	XX
11	3	4480.0	XX
1	3	4676.67	X
7	3	4716.67	X



ANOVA Table for Mercury by site#

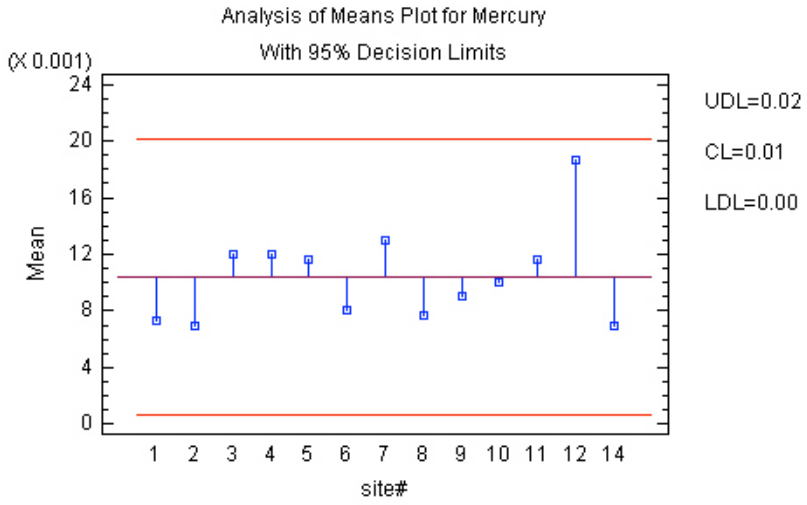
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.000393897	12	0.0000328248	1.05	0.4355
Within groups	0.000811333	26	0.0000312051		
Total (Corr.)	0.00120523	38			

No differences in mercury among areas are indicated.
The multiple range test results are presented here just to display site rankings and mean values per site.

Multiple Range Tests for Mercury by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
2	3	0.007	X
14	3	0.007	X
1	3	0.00733333	X
8	3	0.00766667	X
6	3	0.008	X
9	3	0.009	X
10	3	0.01	XX
11	3	0.0116667	XX
5	3	0.0116667	XX
3	3	0.012	XX
4	3	0.012	XX
7	3	0.013	XX
12	3	0.0186667	X



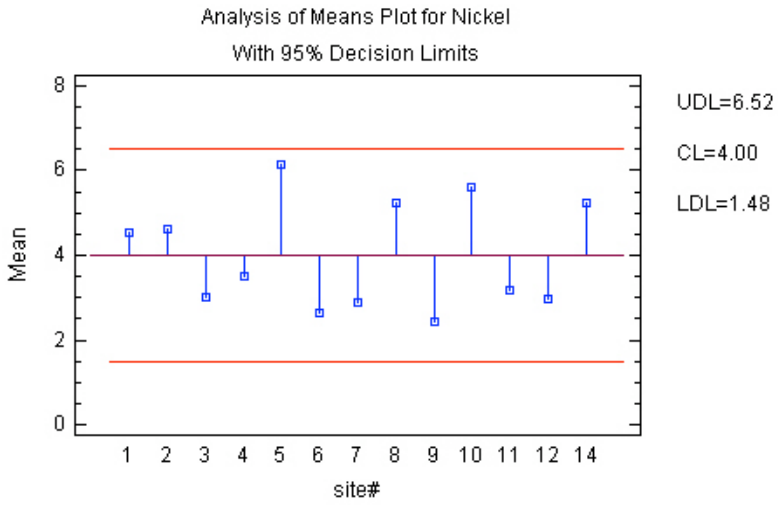
ANOVA Table for Nickel by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	57.78	12	4.815	2.30	0.0366
Within groups	54.4059	26	2.09253		
Total (Corr.)	112.186	38			

Multiple Range Tests for Nickel by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	2.44667	X
6	3	2.62333	X
7	3	2.87333	XX
12	3	2.99	XX
3	3	3.03	XX
11	3	3.18333	XX
4	3	3.49333	XXX
1	3	4.51667	XXXX
2	3	4.61	XXXX
14	3	5.22	XXX
8	3	5.25	XXX
10	3	5.61667	XX
5	3	6.12	X



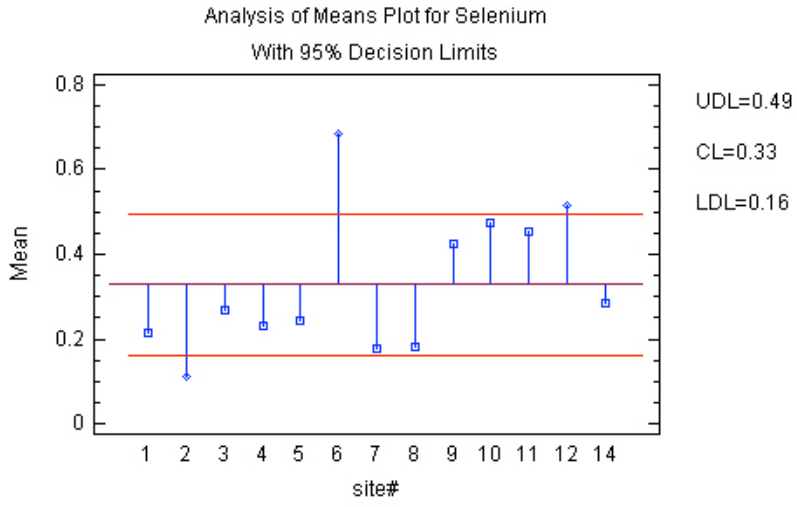
ANOVA Table for Selenium by site#

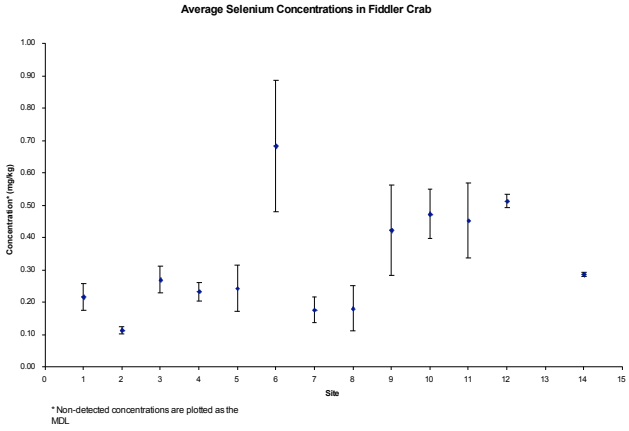
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.993041	12	0.0827534	9.20	0.0000
Within groups	0.233933	26	0.00899744		
Total (Corr.)	1.22697	38			

Multiple Range Tests for Selenium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
2	3	0.113333	X
7	3	0.176667	XX
8	3	0.18	XX
1	3	0.216667	XX
4	3	0.233333	XX
5	3	0.243333	XX
3	3	0.27	XXX
14	3	0.286667	XX
9	3	0.423333	XX
11	3	0.453333	X
10	3	0.473333	X
12	3	0.513333	X
6	3	0.683333	X





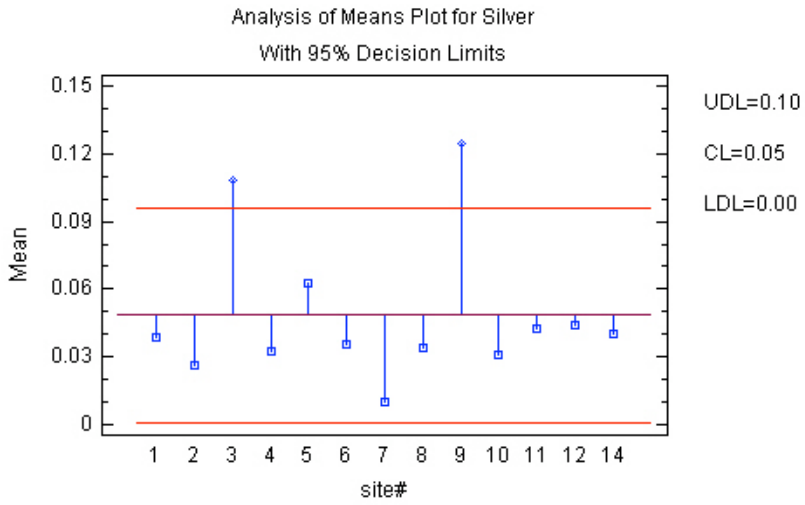
ANOVA Table for Silver by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.0376511	12	0.00313759	4.27	0.0010
Within groups	0.0191164	26	0.000735248		
Total (Corr.)	0.0567675	38			

Multiple Range Tests for Silver by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
7	3	0.0103333	X
2	3	0.0263	XX
10	3	0.031	XX
4	3	0.0323333	XX
8	3	0.0340667	XX
6	3	0.0353333	XX
1	3	0.0386667	XX
14	3	0.0400333	XX
11	3	0.0426667	XX
12	3	0.0443333	XX
5	3	0.0623333	X
3	3	0.108	X
9	3	0.124	X



ANOVA Table for Thallium by site#

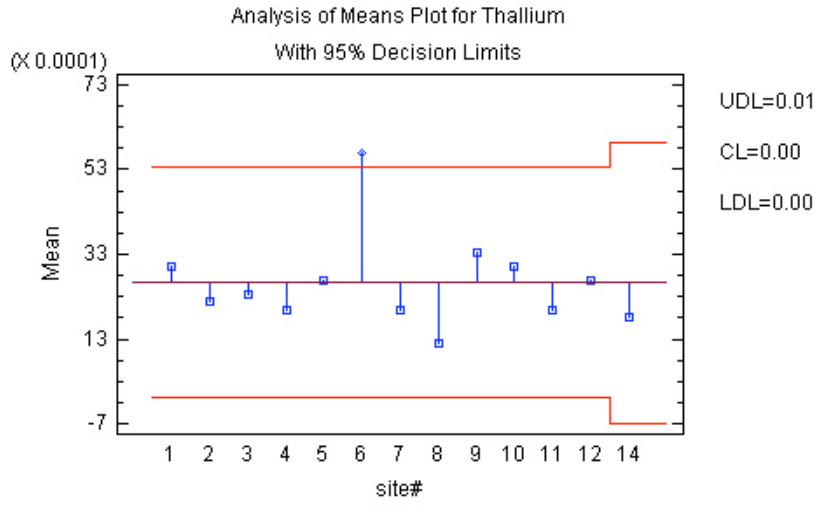
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.0000418804	12	0.00000349003	1.44	0.2110
Within groups	0.0000603933	25	0.00000241573		
Total (Corr.)	0.000102274	37			

No differences in thallium among areas are indicated.
The Multiple range test results are presented here just to display site rankings and mean values per site.

Multiple Range Tests for Thallium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
8	3	0.0012	X
14	2	0.0018	X
4	3	0.002	X
7	3	0.002	X
11	3	0.002	X
2	3	0.0022	X
3	3	0.00233333	X
12	3	0.00266667	X
5	3	0.00266667	X
1	3	0.003	X
10	3	0.003	X
9	3	0.00333333	XX
6	3	0.00566667	X



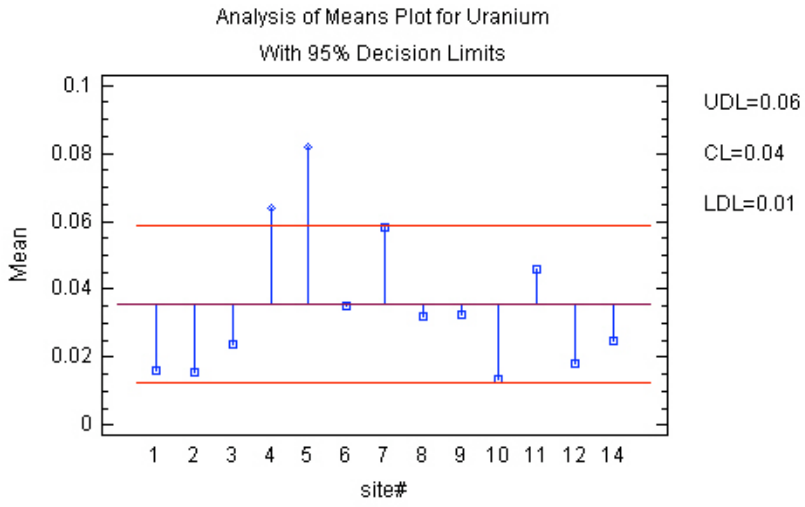
ANOVA Table for Uranium by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	0.016345	12	0.00136208	7.75	0.0000
Within groups	0.00456663	26	0.00017564		
Total (Corr.)	0.0209116	38			

Multiple Range Tests for Uranium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
10	3	0.0133333	X
2	3	0.0154333	X
1	3	0.016	X
12	3	0.018	X
3	3	0.0236667	X
14	3	0.0248	XX
8	3	0.032	XX
9	3	0.0323333	XX
6	3	0.0353333	XX
11	3	0.046	XX
7	3	0.058	X
4	3	0.064	XX
5	3	0.082	X



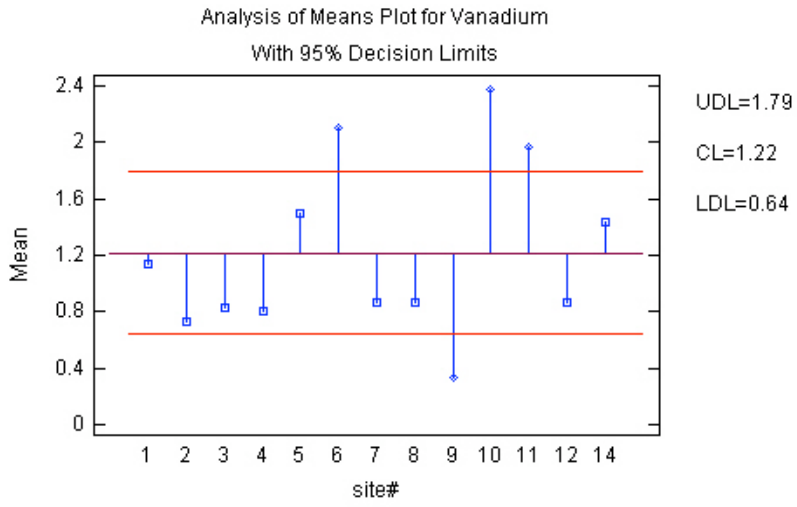
ANOVA Table for Vanadium by site#

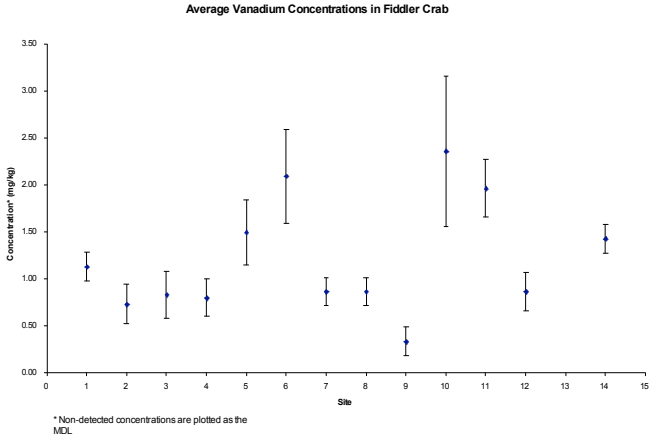
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	13.5041	12	1.12534	10.35	0.0000
Within groups	2.82667	26	0.108718		
Total (Corr.)	16.3308	38			

Multiple Range Tests for Vanadium by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
9	3	0.333333	X
2	3	0.733333	XX
4	3	0.8	XX
3	3	0.833333	XX
8	3	0.866667	XX
7	3	0.866667	XX
12	3	0.866667	XX
1	3	1.13333	XX
14	3	1.43333	XX
5	3	1.5	XX
11	3	1.96667	XX
6	3	2.1	X
10	3	2.36667	X





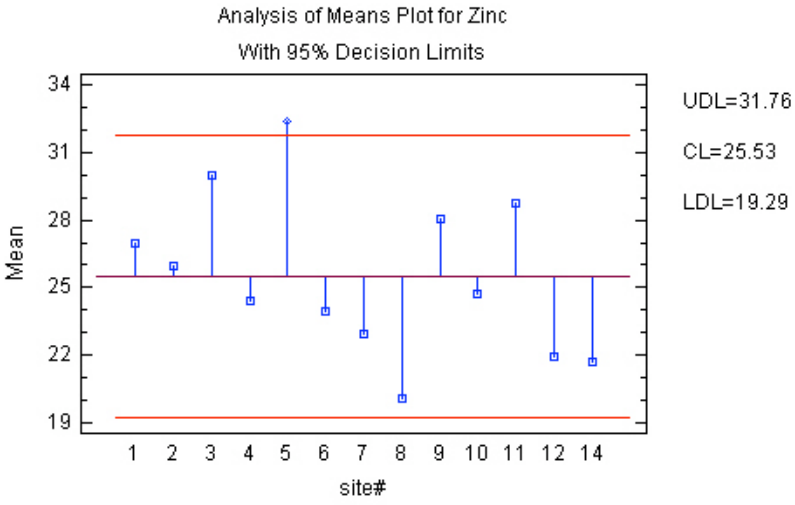
ANOVA Table for Zinc by site#

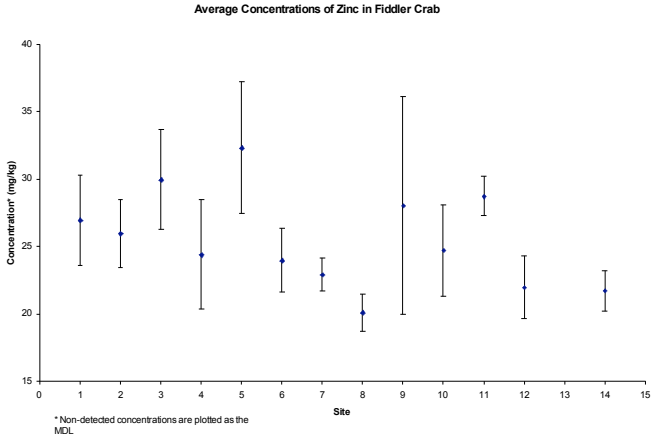
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	457.341	12	38.1118	2.97	0.0098
Within groups	333.613	26	12.8313		
Total (Corr.)	790.954	38			

Multiple Range Tests for Zinc by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
8	3	20.1	X
14	3	21.7333	XX
12	3	21.9667	XX
7	3	22.9333	XXX
6	3	23.9667	XXXX
4	3	24.4	XXXX
10	3	24.7333	XXXX
2	3	25.9667	XXXX
1	3	26.9667	XXXX
9	3	28.0333	XXX
11	3	28.7333	XXX
3	3	29.9667	XX
5	3	32.3333	X





ANOVA Table for tDDT by site#

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Between groups	97970.7	12	8164.22	4.85	0.0004
Within groups	43792.3	26	1684.32		
Total (Corr.)	141763.	38			

Multiple Range Tests for tDDT by site#

Method: 95.0 percent LSD

site#	*Count*	*Mean*	*Homogeneous Groups*
6	3	0.75	X
4	3	1.29333	XX
1	3	1.36667	XX
14	3	1.6	XX
2	3	3.86333	XX
5	3	5.57	XX
12	3	5.94667	XX
8	3	36.1867	XXX
7	3	39.83	XXX
10	3	48.63	XXX
3	3	69.7667	XX
11	3	97.9633	X
9	3	176.88	X